Unit Title:
Grades 6-8: Total Solar Eclipse Phenomena
Standard http://ed.sc.gov/scdoe/assets/file/agency/ccr/Standards-Learning/documents/South_Carolina_Academic_Standards_and_Performance_Indicators_for_Science_2014.pdf

The solar eclipse phenomena finds direct correlation to 8th grade Earth Science and Physical Science standards. However, 6th grade and 7th grade teachers are encouraged to use these resources below to teach their students about the unusual phenomenon that is occurring across our state, a total solar eclipse. It is important that all students, regardless of grade, be prepared for this amazing science phenomenon preceding the event on August 21, 2017. The information below begins with the overall learning needed for all 6-8 students and then continues with deeper extension activities designed to enhance interest in, understanding of, and appreciation for this once in a lifetime event.

8th grade:
Standard 8.E.4: The student will demonstrate an understanding of the universe and the predictable patterns caused by Earth's movement in the solar system.

7th grade:
Standard 7.EC.5: The student will demonstrate an understanding of how organisms interact with and respond to the biotic and abiotic components of their environments.

6th grade:
Standard 6.E.2: The student will demonstrate an understanding of the interactions within Earth's systems (flow of energy) that regulate weather and climate.

New Academic Vocabulary

Some students may need extra support with the following academic vocabulary in order to understand what they are being asked to understand and do. Teaching these terms in an instructional context is recommended rather than teaching the words in isolation. A great time to deliver explicit instruction for the terms would be during the modeling process. Ultimately, the student should be able to use the academic vocabulary in conversation with peers and teachers. These terms are pulled from the essential knowledge portion of the Support Doc 2.0 (http://ed.sc.gov/instruction/standards-learning/science/support-documents-and-resources/) and further inquiry into the terms can be found there.

Eye safety	Greatest duration	Path of totality	Total solar eclipse	Totality	Umbra

Prior Knowledge
• 1.E.3 – Motion of the moon across the night sky • 1.E.3A.3 – Basic knowledge of how technology helps humans study the sun, moon, and stars • 1.E.3A.4 – Effect of sunlight on earth's surface • 1.P.2A.2 – Light behavior when shined on an object • 1.P.2A.3 – Shadows change when the light source changes position. • 4.E.3B.1 – Patterns in the location, movement, and appearance of the moon • 4.E.3B.3 – Shadow observations • 4.E.3 - Solar system
Subsequent Knowledge
• H.E.2 - Structure, properties, and history of the observable universe

Teacher Background Information on Total Solar Eclipse
• *Solar Eclipses for Beginners*: What is an eclipse of the sun? What causes eclipses and why? How often do eclipses happen and when is the next eclipse of the sun? You'll learn the answers to these questions and more in MrEclipse's primer on solar eclipses. This site provides a wealth of general information about solar eclipses. http://www.mreclipse.com/Special/SEprimer.html • "An Observer's Guide to Viewing the Eclipse": This article published in the March 2017 edition of *The Science Teache*r magazine is adapted from the book *Solar Science* by Dennis Schatz and Andrew Fraknoi. static.nsta.org/extras/solarscience/SolarScienceInsert.pdf • "Get Ready for the Great American Eclipse!: A once-in-a-lifetime event provides an opportunity to increase science literacy": This article published in the January 2017 edition of *Science and Children* offers insight into the August 21, 2017 eclipse and outlines the importance of fostering scientific literacy when teaching about the eclipse. http://static.nsta.org/files/sc1705_60.pdf • What to See During an Eclipse: The Exploratorium explains and illustrates notable events to be observed during a total solar eclipse. https://www.exploratorium.edu/eclipse/what-to-see-during-eclipse • What is a Solar Eclipse? Understanding Solar Eclipse: Astronomy and Space for Kids: A quick video that explains the three types of solar eclipses. https://www.youtube.com/watch?v=is8OLhGgLAE • *"Did ancient people really predict solar eclipses?":* This question is answered on the *Ask the Space Scientist* page in NASA's Imagine Education Center. It contains Information from NASA on solar eclipse predictions in earlier cultures. https://image.gsfc.nasa.gov/poetry/ask/a11846.html

Instructional Strategies/Lessons

Strategies and lessons that will enable students to master the standard and/or indicator.

1. Eye Safety

Essential Question: How can I safely watch the entire total solar eclipse?

- Eye safety information: All students should receive careful instruction in this area. Concerns for eye safety during a total solar eclipse provided by NASA can be found using this link. https://eclipse.gsfc.nasa.gov/SEhelp/safety.html
- Information concerning the importance of eye safety, brands of viewers that are available for sale, and the standards they must meet. https://eclipse.aas.org/eye-safety/iso-certification
- This one page eye safety is sponsored by the American Astronomical Society, American Academy of Ophthalmology, NASA, American Academy of Optometry, and the National Science Foundation. https://eclipse.aas.org/sites/eclipse.aas.org/files/AAS-Solar-Eclipse-Safety-v160824.pdf
- Students could develop a model of a pinhole viewer using sheets of paper that safely allows them to view the eclipse. http://static.nsta.org/extras/solarscience/chapter3/3.10PinholeProjectionUsingTwoSheets.pdf
- Students could develop a model of a pinhole viewer in a box. http://static.nsta.org/extras/solarscience/chapter3/3.10PinholeProjectionInABox.pdf
- Students could develop a pinhole eclipse viewer using a mirror. http://static.nsta.org/extras/solarscience/chapter3/3.10ProjectionUsingAMirror.pdf
- Students could build a sun viewer using a pair of binoculars, a tripod, and a large piece of white paper or fabric to project the solar image onto. This is a method similar to the one used by Galileo. https://www.exploratorium.edu/eclipse/video/how-build-sun-viewer
- Students will create a device that allows them to view a solar eclipse. Also included in the lesson are introductory videos/vocabulary, safety, the building instructions, viewing assignment, and follow-up assignments. http://www.nationalgeographic.org/activity/build-a-solar-eclipse-viewer/

2. Exploration of a Total Solar Eclipse

A. Possible Introductory Activities Through Asking Questions and Defining Problems: *Choose from the following bulleted items to elicit student thinking about total solar eclipses through asking questions. Science begins with questions about phenomena, seeking to gather the evidence necessary to construct an explanation about the phenomena. Asking questions leads towards inquiry and drives science and engineering. It is an essential practice to developing scientific habits of mind. These questions are driven by curiosity, by the desire to understand a phenomenon, or by the need to solve a problem. In science, a question should always lead to an investigation to acquire the necessary evidence in an attempt to answer that question.*

Essential Question: Why will there be darkness during the day on August 21, 2017?

- **Weather Satellite Video of a Total Solar Eclipse:** Elicit student thinking about eclipses and what causes them by showing a time-lapse video recorded by the weather satellite Himawari-8 of a total solar eclipse passing over the Pacific Ocean. To make discussion about the phenomenon richer and to allow patterns in student thinking to emerge naturally, the teacher should not reveal any information about the source or content of the video. Before viewing, introduce the idea that each student will be asked to share one thing about the video that stands out to them and each should be ready to explain why this thing caught his/her interest. Once all students have shared, ask students to volunteer questions that come to mind while watching the video. Encourage other students to build upon the questions of others and to share their thinking about possible answers. As much as possible, allow the discussion to be student-driven, but redirect the discussion when needed. Be sure that students discuss what they think might be causing the phenomenon depicted and probe deeply by asking students to explain their thinking. Do not yet explain to students they are observing the moon's shadow travel across the Earth and that they are observing an eclipse from space. Because the video is very short, the teacher may need to replay it multiple times as the discussion progresses. Students may need to see it several times to analyze the images and form questions and answers. At the Digital Typhoon: Total Solar Eclipse of March 9, 2016 website, find the "Animation" header and click on the "RGB" link below it to view the video. http://agora.ex.nii.ac.jp/digital-typhoon/solar-eclipse/20160309/
- **Deep Space Climate Observatory (DSCOVR) Images of Total Solar Eclipse:** Download high definition images captured by NASA's DSCOVR geostationary satellite of the shadow of a total solar eclipse crossing the face of the earth to supplement class discussion regarding the weather satellite video referenced above. Since the effects of gravity on orbiting objects is part of the eighth grade standards, mention this satellite is in orbit at a location called Lagrange point 1. This is a gravitational mid-point at which the gravity from the earth and the sun keep the satellite in a stable orbit at a distance of 1.6 million km (1 million miles). https://earthobservatory.nasa.gov/IOTD/view.php?id=87675&eocn=home&eoci=iotd_image
- **Deep Space Climate Observatory (DSCOVR) Animation of the Moon Crossing the Face of the Earth** After viewing the weather satellite video of a total solar eclipse referenced above and having students discuss the phenomenon and predict what might be causing it, present this animation of the moon crossing the face of the earth produced with images from the DSCOVR geostationary satellite. Elicit student ideas by asking the following questions: 1. What stands out to you about these images? 2. What questions come to mind while viewing these images? 3. What do you think is happening in this sequence of images? 4. How are these images related to the ones from the weather satellite video? 5. What might be the relationship between the objects depicted in the images? It is very important that the teacher not reveal the "right" answers during this discussion and that the students are given the opportunity to safely share their thinking and answers with each other. https://www.nasa.gov/feature/goddard/from-a-million-miles-away-nasa-camera-shows-moon-crossing-face-of-earth

- **Time-lapse video from Iceland** and **Time-lapse simulation of the August 21, 2017 total solar eclipse:** After viewing the weather satellite and DSCOVR videos, have students view videos of a total solar eclipse from the surface of the earth. Students should, by this time, have come to the conclusion that the phenomenon being observed in all videos and images is a total solar eclipse. Students observe a time-lapse video of a total solar eclipse from Iceland. Again, ask students the following questions: 1. What stands out to you about these images? 2. What questions come to mind while viewing these images? 3. What do you think is happening in this sequence of images? 4. How are these images related to the ones from the weather satellite and DSCOVR videos? 5. What might be the relationship between the objects depicted in the images?
  Iceland video: https://www.youtube.com/watch?v=ZAxl0S7za8I
  Aug 21, 2017 simulation: https://www.youtube.com/watch?v=vzJqeyxye_E

Literary techniques to support learning goal: *The following explains two literary techniques that will enrich the inquiry techniques above and engage students in transacting with text to deepen understanding of the total solar eclipse. Teachers may choose a literary technique and a bulleted text, video, or resource below to assist in creating the learning centered on asking questions and transacting with text. These strategies can be used before, during, or after any guided content.*

1. **Say/Mean/Matter** *(Burnett & McEewan-Adkins, 2013): Students should be given a purpose for reading in the form of a question. With the students, read through the text modeling your thinking as to what you highlighted for keywords that help answer the purpose question. Then verbally discuss your thinking to annotate in the margins your response to the text (opinion, questions, or pushback). Ask students to continue that process as they continue to read the text by highlighting key words or phrases within the text that answers the question and annotating their response. Next, have students draw a three column T-chart on paper. On the left side of the chart, write "Say". In the middle of the chart, write "Mean"; and on the right side of the chart, write "Matter".*

Say	***Mean***	***Matter***
Quotes or paraphrasing directly from the text.	*What does the "Say" mean to you in reference to answering the purpose question?*	*Why does the "Say" matter to the context of the topic in reference to answering the question?*

Walk through the first few highlighted key words or phrases with the students to fill in the "Say" column. Then, lead the students in a discussion on what "Say" means and as a group decide what to put in the "Mean" column. Lastly, lead the students in a discussion on why the "Say" matters and decide as a group what to put in the "Matter" column. Let students continue the chart using the remaining portion of the text. This can be done in collaborative groups or independently. Once students have their Say/Mean/Matter charts completed, guide them in writing a response to the purpose question using the information from the Say/Mean/Matter chart.

2. **Annotating for Aha Moments** *(Beers and Probst, 2012): First, explain to students that their insight or sudden understanding reveals something important about what they have read. The teacher will ask the students to look for moments that make them think, "Oh, I hadn't thought of that before," or "I hadn't realized this was possible." Ask yourself, "Why might this realization be important?" Then, tell students that they should have a minimum of one Aha moment per finding. Lastly, ask students to create a four column T-chart on paper. With the students, read through the text modeling your thinking as to what you highlighted for Aha moments. Then verbally discuss your thinking to annotate in the margins your realizations from the Aha moment. Ask students to continue that process as they continue to read the text. As students complete the text, model completing the chart directly from your highlights and annotations. Monitor students as they work on their charts.*

What words told you this was going to be an Aha moment?	***Pg.#***	***What realization came to your mind while reading the text?***	***Why is this realization important?***

Choose from the following resources to support student engagement with the total solar eclipse and transaction with text.

Literary/Informational Texts:

- **<u>Sun Moon Earth: The history of solar eclipses from omens of doom to Einstein and exoplanets</u>** by Tyler Nordgren: In this book, astronomer Tyler Nordgren illustrates how this most seemingly unnatural of natural phenomena was transformed from a fearsome omen to a tourist attraction (ISBN: 9780465060924). This book is also available in audio (AISN: B01M31NZ78).
- **<u>When the Sun Goes Dark</u>** by Andrew Fraknoi and Dennis Schatz: This illustrated book prepares young astronomers for the August 21, 2017 eclipse. The book tells how two curious children and their grandparents re-create eclipses in their living room using a lamp, a tennis ball, two Hula Hoops, and table tennis balls. Later, in the backyard and around the house, the family explores safe ways to view a solar eclipse and ponder phenomena from sunspots to phases of the Moon.
 (ISBN: 9781681400112 (print) or ISBN 9781681400129 (e-book)
- **<u>Total Addiction: The Life of an Eclipse Chaser</u>** by Kate Russo: In this book, Kate Russo describes the wonder and thrill of seeing a total solar eclipse. After seeing one, many people want more; and they are willing to go to great lengths and often great expense to repeat the experience. What is it like to experience totality? What is it about the experience that motivates these eclipse chasers? Is there an eclipse chaser personality? Can eclipse chasing actually be described as an addiction? This book describes the people who dedicate their lives to chasing their dream (ISBN 9783642304811).
- **"The Eclipse"** by James Fenimore Cooper is an autobiographical vignette written between 1833 and 1838. James Fenimore Cooper recounts his own experience witnessing a solar eclipse in Cooperstown on the morning of June 16, 1806. The author's daughter found it among her father's papers after his death and had it published.

https://americanliterature.com/author/james-fenimore-cooper/short-story/the-eclipse

- ***Beyond a Shadow of a Doubt: the Science Behind Eclipses*** is a website that contains a description of the conditions necessary for both solar and lunar eclipses and is linked to a quiz designed to measure student comprehension of the concepts involved. http://www.algebralab.org/passage/passage.aspx?file=EarthSpace_Eclipses.xml
- **"Nightfall"** by Isaac Asimov is a science-fiction story about the coming of darkness to the people of a planet ordinarily illuminated by sunlight at all times. The story explores the fear and unpredictable reactions that unnatural darkness can provoke. http://www.astro.sunysb.edu/fwalter/AST389/TEXTS/Nightfall.htm

Videos and other resources:

- **2017 Eclipse and Moon's Orbit:** This animation from NASA's Scientific Visualization Studio shows the relationship of the sun, earth, and moon during the August 21, 2017 Total Solar Eclipse. The accompanying article explains the conditions necessary for a total solar eclipse. https://svs.gsfc.nasa.gov/cgi-bin/details.cgi?aid=4324
- **Visualizing the 2017 All-American Eclipse:** This video from NASA's Scientific Visualization Studio features several visualizations of this event. From behind the earth, it depicts the night sides of both the earth and moon and the umbral and penumbral shadow cones projecting from the moon. It also shows the tilted orbit of the moon and the long, thin shadow cones striking the earth. In the view from behind the moon, the daylight far side of the moon and the western hemisphere of the earth are visible; and from this vantage point, the outline of the shadow on the earth is circular. Most of the video shows a close-up view of the U.S. during the eclipse; and the narrator explains that everyone in the US will see an eclipse, but only those along the path of totality will see a total solar eclipse. https://svs.gsfc.nasa.gov/12117
- **A Rare, Spectacular Total Eclipse of the Sun:** In this TED-Ed video geared towards school children, Andy Cohen explains how the tiny moon can eclipse the sight of the sun. Both the historical significance of solar eclipses and the process required to produce solar eclipses are explained. http://ed.ted.com/lessons/what-creates-a-total-solar-eclipse-andy-cohen

B. Total Solar Eclipse Exploration Through Modeling: *Choose from the following bulleted items to elicit student thinking about total solar eclipses through modeling. The Science and Engineering Practice of developing and using models is used to understand and represent the total solar eclipse phenomena, processes, and relationships. Models may serve as a way to answer scientific questions asked above by students. Below you will find multiple modeling strategies to choose from to engage your students in this SEP while learning about the total solar eclipse phenomena. Each student should have the opportunity to participate in at least one of these structured investigations to model a total solar eclipse.*

Essential Question: How does the position of the moon, sun, and earth cause a total solar eclipse to occur?

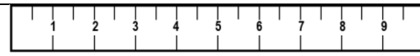
- **What is the Best Model for the Earth-Moon-Sun System?** Once students have an understanding that an interaction of the sun, earth, and moon produces the total solar eclipse phenomenon on earth's surface, ask students to evaluate and rank several sun-earth-moon system models in terms of their usefulness in modeling a total solar eclipse. Have students work in small groups to arrange the models from strongest to weakest and provide pros and cons for each model type. As an extension, ask student how they would improve the strongest model to make it even better. Look for the manipulative under Earth Science, third bullet titled "Earth/Sun/Moon Models" to find the pdf of the different models to be analyzed. http://www4.esc13.net/science/resources-science/manipulatives/#Earth_science
- **Model Eclipse with Styrofoam Balls:** Students use Styrofoam balls to construct models of the cause and effect of the relative motions of the sun, earth, and moon during a solar eclipse. They manipulate the components to project a shadow analogous to that of an eclipse. http://www.unawe.org/activity/eu-unawe1302/
- **Eclipsing the Sun:** This is a 3-D model using three different sized inflatable balls to model the cause and effect of a total solar eclipse. A ball 36 inches in diameter (sun), a ball 12 inches in diameter (earth), and a ball 8 inches in diameter (moon) are used for this modeling activity. In a darkened room and using a flashlight, students move into the relative positions to create an analogue of the solar eclipse. https://sunearthday.nasa.gov/2006/images/eclipsing_the_sun2.pdf
- **"Modeling the Eclipse":** This article by William Thornburgh and Thomas Tretter published in the March 2017 edition of the NSTA journal *The Science Teacher* describes a unit in which students investigate from several perspectives the total solar eclipses, such as the one coming August 21, 2017. It incorporates mathematical thinking. http://static.nsta.org/files/tst1703_47.pdf
- **"Exploring Lunar and Solar Eclipses via a 3-D Modeling Design Task":** In this article, the authors demonstrate an approach for developing, enlarging, and refining students' initial ideas about lunar and solar eclipses. Students are provided an opportunity to refine their thinking about eclipses and to reflect on how their ideas have changed. http://static.nsta.org/files/ss1602_30.pdf

C. Total Solar Eclipse Exploration Through Analyzing and Interpreting Data: *Choose from the following bulleted items to elicit student thinking about total solar eclipses through analyzing and interpreting data. The Science and Engineering Practice of analyzing and interpreting data is used to understand what occurs during the total solar eclipse phenomena. Analysis and interpretation of data may serve as a way to answer scientific questions asked by students. Each student should have the opportunity to participate in the collection and analysis of data while participating in a structured investigation.*

Essential Question: What is the path and timing of the total solar eclipse?

- **When will the Eclipse Happen Where I Am?:** Students enter unique coordinates to determine specific details about the eclipse at a designated location, like their school. The website is http://aa.usno.navy.mil/data/docs/Eclipse2017.php. Data is entered in form B. At the bottom of the page, students can enter a query using the GNIS link to obtain needed latitude, longitude and elevation for the specific location they choose. Students will learn about the altitude and azimuth, important angles used in astronomy. Interpreting data can involve comparing results of different searches or simply converting UDT to EDT.

- **Path of Totality and Greatest Duration**: This comprehensive website (Eclipse 2017.org) has about any type of information you could possibly think of relating to the solar eclipse in August. Especially interesting is Xavier Jubier's 2017 Total Eclipse Interactive Map which allows you to zero in right on the place from which you will be viewing the eclipse, it and gives you the exact times based on Universal Time (UT) from beginning, totality, and end of the event. Students will be exposed to UT and latitude/ longitude when using this map. The students can determine the specific latitude and longitude of their own location, the start-finish of the eclipse, and the duration of totality.
  http://www.eclipse2017.org/eclipse2017_main.htm
- **Estimating the Speed of the Lunar Shadow:** Students use mathematical and computational thinking to calculate the diameter of the moon's shadow and the velocity of the moon's umbra across the US using information from a data table generated by NASA.
  https://eclipse2017.nasa.gov/sites/default/files/Math_Challenge5_.pdf
- **Insolation during the 2017 Eclipse** This visualization from NASA tracks the changing insolation along the path of the August 2017 eclipse across the US. While most middle-school students will not understand the sine of an angle (in this case solar altitude), it can be explained that as the sun gets higher in the sky, the amount of heating increases as well. This relates directly to the seasons indicator for eighth grade (8.E.4B3). The essential knowledge here is that as the sun gets higher in the sky, the amount of heating increases as well.
  https://svs.gsfc.nasa.gov/4466
  - Applicable vocabulary:
    insolation- the amount of solar energy reaching earth's surface
    solar altitude- the sun's position above the horizon
    obscuration-refers to how much of the sun is blocked by the moon during the eclipse
  - Possible extensions based on computational and mathematical thinking using this map could include:
    - Have students calculate the distance in kilometers for the northern border of Wyoming. This state was chosen due to the magnitude of the distance which is 342 mi. Using the conversion factor of 1.61 km, the product will be 550.62 km, which can be tweaked to 550 km for the sake of convenience.
      1. Use the map on the link above.
      2. Allow the video to play until the umbra is in the desired position, then pause.
      3. Open Snip Tool or another screenshot utility tool to make a copy of the map.
      4. Paste it on a WORD document or onto a projection board like SmartBoard.

5. Copy this ruler. 

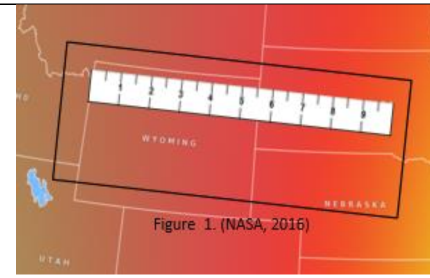


Figure 1. (NASA, 2016)

6. Insert a textbox on the pasted map that has been formatted with no fill color, and paste the ruler into it. (This will allow for the ruler to be manipulated in position and size.)
7. Position the ruler over the northern border of Wyoming, and size the ruler so that 5.5 cm equals the northern border of the state. Clicking on the ruler inside of the textbox allows for sizing so the scale is 1cm = 100 km as shown in Figure 1.
8. Keep the ruler at this scale for the remainder of the activity.
9. Have the students determine an approximate diameter of the umbra using the scaled ruler.
10. Without looking it up on the Internet, have the students determine the approximate length of the path of totality from the start of the eclipse on the west coast to the end of the eclipse on the east coast. The distance will be approximately 3,027 mi or 4,873 km. Students may question the size of the ruler and the ability to measure across the US. This is an exercise in problem solving so allow the students to find their own solution making this measurement.
    - Possible solutions could be marking the coast of Oregon and South Carolina with tick marks on a piece of paper and making a scale of the ruler to determine the distance.
    - Based on the time the eclipse starts on the west coast, students will determine the times for given percentages of insolation. (For example: “At what time will insolation drop to 50% in Columbia, SC?)

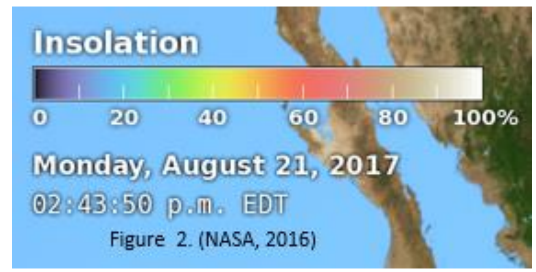


Figure 2. (NASA, 2016)

11. Students will use the distance calculated in the activity above and the time counter from the map to determine the velocity of the umbra across the US. (Figure 2)

D. Exploration of a Total Solar Eclipse Through Constructing Devices and Designing Solutions: *The following bulleted options below can elicit student thinking about total solar eclipses through constructing devices and designing solutions. The goals for this practice are for students to apply scientific concepts and ideas to the solving problems or meeting needs. Students should define problems related to scientific concepts, design and test devices or solutions, and model and propose successful devices or solutions that reflect both an understanding of the underlying scientific concepts under study as well as how those concepts are applied in the solution of a problem or the design of a product that meets a need.*

Essential Question: What is the best way to view the total solar eclipse and other eclipse phenomena without actually looking at the sun?

- **Test Efficacy of Student-Constructed Sun-viewing Methods:** Students will test devices they construct based on the procedures relating to each design and conduct a controlled investigation on what sun-viewing method is the best. In doing this comparison, students will construct different devices. This lesson allows students in groups to test and refine the best technique for viewing solar phenomena-- like sunspots or solar eclipses. Several suggestions for the construction of pinhole cameras (projection devices using binoculars/ telescopes, or just two pieces of cardboard) are listed under "Eye Safety."
    - Each group constructs their assigned or chosen device. Older students may construct the binocular viewers or sun funnels.
    - After construction, the students will test their devices outside and evaluate them based on the quality of the image produced by each one. Other considerations for the device are availability of materials, cost of materials, ease of use, durability, and the images of the sun that are generated by the devices. Device is the independent/ manipulated variable and "image quality" is the dependent/ responding variable. Operational definition of "image quality" could be the clarity of the sun-disc and if any sunspots are visible. A tool for the evaluation of the device is a "POM." This is a short, easy to use snapshot of the phenomenon, the objects/ factors, and the motions being modeled. The student is then asked to provide an explanation and a diagram of the model. Students can be guided through drawing their models to scale and proper labeling techniques. The link has an editable RIF option that will allow modification. http://ncisla.wceruw.org/muse/earth-moon-sun/materials/build/material2E/activities/POM.html
- **Exploring Shadow Bands:** This rare event occurs about a minute or two before and after totality. Shadow bands appear as dancing or waving lines of light and dark that appear on light, flat surfaces. This NASA "Citizen Science" link gives some historical background on shadow bands, and explains how to best capture this by camera, and a list of guiding questions if a group of students wanted to collect data related to the speed and direction of the bands (https://eclipse2017.nasa.gov/exploring-shadow-bands). Another good video of shadow bands is about one minute into this video: https://www.youtube.com/watch?v=37_DinsM-6o.

3. Possible Culminating Activities: *Teachers may choose from the following bulleted options that will focus total solar eclipse learning around constructing explanations, obtaining, analyzing, interpreting, and evaluating data and communicating information.*

Essential Question: How might a solar eclipse be a personally transformative moment?

- **Eclipse Art Quilt:** By participating in this event from the total solar eclipse, students can communicate scientific information and construct explanations artistically, as well as express their own emotions. In NASA's "Eclipse Original Art Quilt, students use pencil, charcoal, colored pencils, oils, acrylics, water medium, mixed media/collage, or computer generated art to produce their own expression of their experience on August 21. The requirements for submission are the following: a picture of your original art work by anyone between the ages of six and up who experienced the August 21, 2017 eclipse. Pictures of the work must be submitted by September 15, 2017, to NASA's Solar Eclipse Flickr Group (https://www.flickr.com/groups/nasa-eclipse2017) or on Instagram using #Eclipse2017Corona. Here is the link to the actual site with all of the information: https://eclipse2017.nasa.gov/eclipse-original-art-quilt.

- **Children's Picture Book Project:** Students create a children's picture book based on information they synthesize from analyzing and interpreting data, obtaining scientific information from primary and secondary scientific literature, and explanations from investigations to teach about solar eclipses and what causes them. A detailed lesson plan for how to go about a coaching students through this complex task has been published by the National Council for Teachers of English and can be found at the following website: http://www.readwritethink.org/resources/resource-print.html?id=1022.
- **Feature News Article:** Students write a feature article using the conventions and expectations of scientific writing for a school newspaper about the August 21, 2017 eclipse. Detailed lesson plans that explains the writing of the feature story in-depth and looks at the different types of feature stories (profiles, backgrounders, community events, etc.) can be found at http://www.schooljournalism.org/feature-writing-lessons/.
- **Eclipse Poetry Project:** Students construct a narrative poem based on information they have gathered from analyzing and interpreting data, from reading primary and secondary scientific literature, and from investigations. The purpose of the poem is to teach about solar eclipses and what causes them. The poems may or may not rhyme but should use specific scientific vocabulary that describe the process and sights of a total solar eclipse: total solar eclipse, first contact, second contact, third contact, fourth contact, umbra, penumbra, moon, sun, corona, totality, photosphere, star, prominences, solar flares, solar wind, etc. The teacher can adjust the vocabulary to be used as needed. The poem should be at least ten lines long, should use ALL of the vocabulary words listed above in a meaningful context, and use the scientific vocabulary properly. Students can use the words in any order as long as the content of the poem lets the reader know the author understands the meaning of the words. Encourage students to use vivid vocabulary. Below is an example of a student poem about the sun, using scientific vocabulary. (Although this poem was written about features of the sun and not specifically about the eclipse, it is a good example of this type of poem.) A poem specifically about an eclipse, but not including much scientific vocabulary can be found at http://www.sciencepoems.net/sciencepoems/solareclipse.aspx#.WJKegRsrKUl.

Spirit of the Sun

By: Claire Bowden

Flames extend miles into space
Solar Flares, at an extraordinary pace
As you look deeper inside
You'll find that plasma can reside

Frequencies can make
The sun ripple like a lake

Because of the star's magnetic storm
Auroras on Earth start to form

As the moon in front passes
Blocking the star made of boiling gases
The corona can be seen
If you are very keen

Or searching for a prominence
That displays a sort of dominance
All of these are parts of the photosphere
Which makes up the Sun’s atmosphere

Solar wind skims the surface
With a very specific purpose
Sunspots are much cooler than the rest
So now you see, that the sun is the very best

- **Busting the Myth:** Students will read solar eclipse myths and legends and construct an explanation of the science behind the event. They will choose one of the myths and write a story as if they were explaining how solar eclipses scientifically occur to someone from the era they chose. For instance after reading the Egyptian legend, they will then write a story explaining the process behind solar eclipses to an ancient Egyptian. There are numerous myth stories listed under teacher resources at http://thechallengercenter.net/?page_id=1768.

- **Being in the shadow:** This is a link to a page in a larger website devoted to experiencing a total solar eclipse by Dr. Kate Russo, an authority and eclipse chaser. This page has a couple of dozen quotes from her book *Totality: The Total Solar Eclipse of 2012* by people who blogged their feelings during the total solar eclipse in Australia in 2012. Students could blog or create blog-like writing to express what they felt during their experiences and share it.
 http://www.beingintheshadow.com/blog-2/

Extension Activities
These strategies and lessons will enable students to understand the total eclipse phenomena with more direct ties to specific grade level Performance Indicators. Teachers are encouraged and have the discretion to use any resources, regardless of grade level, that may strengthen their students' needs and understanding of the total solar eclipse. These are designed to enhance interest in, understanding of, and appreciation for this once in a lifetime event. Performance Indicators are listed below in purple. The text within the Performance Indicators highlighted in *orange* and *italicized/underlined* shows connections to SEPs.

Note: Refer to the literary techniques shared in the previous section to facilitate learning with any literary/informational texts shared below.

Eighth Grade Performance Indicator:
8.E.4B.4 *Develop and use models* to explain how motions within the Sun-Earth-Moon system caused Earth phenomena (including day and year, Moon phases, solar and lunar eclipses, and tides).

Exploration of Other Earth-Moon-Sun System Phenomena:
What other predictable phenomena are caused by earth's movement in the solar system?

Vocabulary: antumbra, tidal range, syzygy, spring tide, aphelion, perihelion, apogee, perigee

1. **Possible Introductory Activities:**
   Choose from the following resources to support student engagement with the total solar eclipse and transaction with text.

   Literary/Informational Texts:
   - **Tides and Water Levels**: In this article set published by the National Oceanic and Atmospheric Administration, students are introduced to the concept of tides and are easily able to find the answers to the questions: What causes tides? What do gravity and inertia have to do with tides? How do the angles of the sun and moon with earth affect tides? How frequently do tides occur? What causes variations in tides? How do we monitor tides?
     http://oceanservice.noaa.gov/education/kits/tides/tides01_intro.html
   - **The Sun and the Earth-Moon System:** This article published by the CK-12 Foundation gives a brief overview of the day-night cycle, the reason for earth's seasons, solar eclipses, lunar eclipses, the phases of the moon, and the tides. Videos helpful to understanding the phenomena are either embedded in the article or are linked.
     http://www.ck12.org/book/CK-12-Earth-Science-For-High-School/section/24.4/

2. **Instructional Strategies:**
- **Exploration of Shadows in the Earth, Moon, and Sun System: Moon Phases and Eclipses:** This is a guided inquiry in which students use models of the earth (a globe or softball), the moon (Styrofoam ball or a ping-pong), and the sun (desk lamp or overhead projector) to

explore the interactions of shadows in the earth, moon, and sun system. Students create variations of alignment with the model components to cast shadows and observe lit and non-lit portions of the earth and moon. Students manipulate and observe their 3-D models as they simulate the movement of these bodies through rotation and revolution. Teachers guide students to discover moon phases, lunar eclipses, and solar eclipses prior to learning about the phenomena and definitions in a traditional way. After their observations, they draw 2-D representations and develop further questions about their models and the natural phenomena.
http://serc.carleton.edu/sp/mnstep/activities/35029.html

- **Scale Models:** Without being informed of the expected product, the students will make a Play-doh model of the earth-moon system, scaled to size and distance. The facilitator will reveal the true identity of the system at the conclusion of the activity. During the construction phase, students try to guess what members of the solar system their model represents. Each group receives different amounts of Play-doh, with each group assigned a color (red, blue, yellow, white). At the end, groups set up their models and inspect the models of other groups. They report patterns of scale that they notice: As the amount of Play-doh increases, for example, so do the size and distance of the model.
https://stardate.org/sites/default/files/pdfs/teachers/ScaleModels.pdf
- **Knowing North: Understanding the Relationship Between Time and the Sun:** Students learn how the ancient Chaco Canyon civilization created a time-keeping device by creating a place where the movement of the sun could be tracked day after day. Chacoans marked the passage of time and gained an idea of when seasons were changing so that they knew when to plant their crops for best success. They discovered the cyclical relationship between the passage of time and where the earth is in its daily and yearly rotations. Students then used modeling and mathematical thinking to create their own time-keeping device using the sun and a rod. They gather data and analyze the movement of shadows cast by the rod over the course of several days and not only experience how the sun can help us measure time, but also how to find true North based on the time and the direction shadows point at that time.
http://www.exploratorium.edu/chaco/HTML/TG-north.html
- **Modeling how lunar eclipses and solar eclipses differ:** Using the models created using Styrofoam balls, students demonstrate the cause and effect of a lunar eclipse. **Modeling of a total eclipse of the Sun by Earth** from an observer on the moon can be accomplished using this investigation. This uses the previous link: http://www.unawe.org/activity/eu-unawe1302/. Students will explain what an observer on the moon would see: the earth with a red ring around it as the earth obscures the sun. The earth is much larger, therefore very little of the corona would be visible. Here is a video showing a visualization of a solar eclipse as viewed from the moon.
https://svs.gsfc.nasa.gov/cgi-bin/details.cgi?aid=4341
- **Predict what the tides would be like on the day of a solar eclipse:** Give students a tidal chart for the current month. This link will open a page with a listing of the NOAA gaging stations along the South Carolina coast from which there are multiple locations from which to chose: https://tidesandcurrents.noaa.gov/tide_predictions.html?gid=1412.
Project a moon phase calendar from the previous month: http://www.moonconnection.com/moon_phases_calendar.phtml .
Based on what students know about the phase cycle and the relative positions of the sun, earth, and moon they will:
    - Analyze the dates of the phases from the previous month and infer the date of the new moon for the current month.

- Use mathematical and computational thinking to identify when the tidal ranges are increasing.
- Observe the tidal ranges increasing in the week leading up to the new moon and on what day the spring tide occurs.
- Evaluate and predict the date on which a solar eclipse could occur and justify their prediction based on the relative positions of the SEM system and the tidal range.

Exploration of Other Earth-Moon-Sun System Phenomena
Will we always see a total solar eclipse?

- ***How Can the Little Moon Hide the Giant Sun?:*** This activity was geared toward lower grade levels but could be made appropriate for higher grades by having students record distances needed to "eclipse" the larger ball. This is good practice in measurement and the recording of data. Students can also compare the distances required for two different balls (a medium sized and a small one) to cover up the larger ball and explain how the models are analogs for the sun and moon.
http://www.eyeonthesky.org/lessonplans/12sun_littlemoon.html
- **The Last Total Solar Eclipse on Earth**: Students use mathematical and computational thinking to calculate approximately how many years will pass until the day comes when the moon will be too far away from earth to create a total solar eclipse.
https://eclipse2017.nasa.gov/challenge-13-—-last-total-solar-eclipse-earth

Eighth Grade Performance Indicator:
8.E.4B.6 *Analyze and interpret data* from surface features of the Sun (including photosphere, corona, sunspots, prominences, and solar flares) to predict how these features may affect Earth.

Exploring the Effects of Sun's Surface Features on Earth
How does solar activity affect Earth?

Vocabulary: photosphere, corona, sunspots, prominences, solar flares, solar wind, magnetic field, magnetic storm, magnetosphere, aurora, geostationary satellite

1. **Possible Introductory Activities:**
   - **The Sun:** This Science NetLinks page is sponsored by American Association for the Advancement of Science is a general introduction to the sun. The whole process is guided; included in this page are informational texts in a variety of formats: discussion questions, activities, and assessment suggestions. Students will learn more about the sun's place in the universe, how the sun produces energy, and the life cycle of a star. Two related activities guide students to investigate magnetism and investigate the role magnetism plays in sunspot activity. http://sciencenetlinks.com/lessons/the-sun/

Choose from the following resources to support student engagement with the total solar eclipse and transaction with text.

Literary/Informational Texts:

- **Regions and Features of the Sun:** The structure and surface features of the sun are explained and illustrated clearly in this article that includes hyperlinks which allow students to read more in-depth information about any one feature. https://scied.ucar.edu/sun-features-regions
- **Total Solar Eclipse Viewed from Australia:** This article contains several images showing the corona during totality. https://svs.gsfc.nasa.gov/11133
- **"Space Weather: What impact do solar flares have on human activities?":** In this article, students learn how solar flares affect human activities by disrupting the magnetic field of the earth. Effects on earth-orbiting satellites and power grids at higher latitudes are explained. Links to more information about the effects of solar flares on human activities and how humans have attempted to engineer solutions to prevent the most devastating effects are included at the end of the article. https://hesperia.gsfc.nasa.gov/sftheory/spaceweather.htm

Videos:

- **NASA 5 Year Time-Lapse of the Sun:** The Solar Dynamics Observatory (SDO) captured one frame every eight hours for five years. This time-lapse video puts all the frames together. The different colors represent the various wavelengths (sometimes blended, sometimes alone) in which SDO observes the sun. https://svs.gsfc.nasa.gov/cgi-bin/details.cgi?aid=11762
- **August 31, 2012 Magnificent CME:** On August 31, 2012, a long filament of solar material that had been hovering in the sun's atmosphere, the corona, erupted out into space at 4:36 p.m. EDT. The coronal mass ejection, or CME, traveled at over 900 miles per second. The CME did not travel directly toward earth, but did connect with earth's magnetic environment, or magnetosphere, with a glancing blow, causing aurora to appear on the night of Monday, September 3. Downloadable images and video of these event are available. https://svs.gsfc.nasa.gov/cgi-bin/details.cgi?aid=11095
- **SDO Sees Fiery Looping Rain on the Sun:** Eruptive events on the sun can be wildly different. Some come just with a solar flare, some with an additional ejection of solar material called a coronal mass ejection (CME), and some with complex moving structures in association with changes in magnetic field lines that loop up into the sun's atmosphere, the corona. On July 19, 2012, an eruption occurred on the sun that produced all three. The footage in this video was collected by the Solar Dynamics Observatory's AIA instrument. SDO collected one frame every twelve seconds, and the movie plays at thirty frames per second, so each second in this video corresponds to six minutes of real time. https://svs.gsfc.nasa.gov/cgi-bin/details.cgi?aid=11168

- **NASA Spacecraft Track Solar Storms from Sun to Earth:** NASA's STEREO spacecraft and new data processing techniques have succeeded in tracking space weather events from their origin in the sun's ultrahot corona to impact with the earth 96 million miles away. This video clearly describes how the STEREO spacecraft allow scientists to study a coronal mass ejection from its birth in the corona to its impact with the magnetic field of the Earth. https://svs.gsfc.nasa.gov/cgi-bin/details.cgi?aid=10809
- **Solar Cycle Primer:** The solar cycle including sunspot activity and magnetic pole flips is explained. https://www.nasa.gov/mission_pages/sunearth/news/solarcycle-primer.html

2. Instructional Strategies:

- **NOVA Sun Lab:** This investigation guides students through three introductory parts, each with three short videos, and ends with an investigation. For students who may be in sixth and seventh grade, "Sun 101" might be helpful in leading them into understanding what they will see during the total solar eclipse. The latter parts of lesson are not necessary for understanding the basic parts and features of the sun they will observe in August. For eighth grade, the entire lesson is valuable in guiding them to understand the sun and its effects on earth. By moving through the introduction, students have the ability to take notes and answer a few questions before being allowed to progress to the next part. These notes are saved in the "lab report" which is the culminating part of the activity.

NOVA Sun Lab- http://www.pbs.org/wgbh/nova/labs/lab/sun/research

1. "Sun 101" gives the students background on the composition and structure of the sun, describes the source of the sun's energy, and ends with an explanation of how magnetism gives variability in the surface behaviors we have observed. The last part of Sun 101 also mentions the eleven year sunspot cycle.
2. The next part called "Space Weather" explains what causes space weather. The second part of this section explains the magnetosphere and how it protects earth from the harmful end of the electromagnetic spectrum, and from harmful space weather. The third part of "Space Weather" describes solar storms on earth and how crippling a severe solar storm could be to us.
3. The last part of the introduction, "Technology and Discovery," talks about space observatories and the knowledge these have given scientists here on earth in the quest to understand solar activity. Missions like SOHO, STEREO, and the Solar Dynamics Observatory are described. The purpose of several different instruments being carried by SDO are explained, and the term "helioseismology" is defined and its value to predicting solar storms. Their important discoveries and contributions to solar science are discussed.
4. The last part of this introduction explains how the software works and the purpose of their investigations.
5. The first part of the lab guides students through counting sunspots. It is exacting; and some students may become frustrated, but they are able to use real images and measure sunspot activity.
6. The "Storm Prediction" section give students choices that allow them to predict which sunspot group will most likely erupt.
7. Stop the lesson here. Clicking on the "Open Investigations" tab requires students to log into Facebook, but the earlier parts are worth the time and require careful observation and thought.

- **Solar Stormwatch II Citizen Science Project:** Solar Stormwatch II uses data from the NASA STEREO mission to track eruptions of material from the solar atmosphere as they expand through the inner solar system. Students can become involved and help the Solar Stormwatch team improve their tracking techniques by using analytical thinking and tracing the outline of solar storms in images collected by the STEREO spacecrafts (https://www.zooniverse.org/projects/lepnoir/solar-stormwatch-ii). To find out more about the STEREO mission, view the video NASA Spacecraft Track Solar Storms from sun to earth available at https://svs.gsfc.nasa.gov/cgi-bin/details.cgi?aid=10809.

Seventh Grade Performance Indicator:

7.EC.5A.3 *Analyze and interpret data* to predict changes in the numbers of organisms within a population when certain changes occur to the physical environment (such as changes due to natural hazards or limiting factors).

Effect of Total Solar Eclipse on the Biotic and Abiotic Factors in an Ecosystem
Essential Question: How does a total solar eclipse affect the biosphere?

Vocabulary: behavior, adaptation, nocturnal, abiotic, biotic, population, stimulus, response, convection, meteorology, photosynthesis

1. **Possible Introductory Activities:**

   Choose from the following resources to support student engagement with the total solar eclipse and transaction with text.

   Literary/Informational Texts:

   - **"Solar eclipse: birds to stop singing as Moon passes Sun":** This is a news article published by *The Telegraph* about the March 20, 2015 solar eclipse seen from the United Kingdom that discusses how animals could respond to the unusual darkening and re-brightening of the day.
     http://www.telegraph.co.uk/news/earth/wildlife/11483137/Solar-eclipse-birds-to-stop-singing-as-Moon-passes-Sun.html
   - **"How Cicadas, Squirrels, and Bees React to Solar Eclipses:** This is a news article published by *The Atlantic* describing the behavioral changes of animals before, during, and after eclipses.
     https://www.theatlantic.com/technology/archive/2014/10/how-cicadas-squirrels-and-bees-react-to-solar-eclipses/381842/
   - **"Solar eclipses DO change the weather! Falling temperatures alter the speed and direction of the wind":** This is a news article published by The *Daily Mail* that provides evidence, including graphs and charts, related to weather and temperature during a solar eclipse. Students should be able to explain why the most dramatic finding was the change in wind direction.
     http://www.dailymail.co.uk/sciencetech/article-3749509/Solar-eclipses-change-weather-Falling-temperatures-alter-speed-direction-wind.html
   - **"An Animal's Reaction to a Solar Eclipse"**: Based on observations made during the 2001 eclipse in Zimbabwe, the reaction by hippos

and other animals are described. Observations of the behaviors of other organisms during other eclipses are also included. http://sciencing.com/animals-reaction-solar-eclipse-3503.html

- **"Observing Wildlife Reactions during a Total Solar Eclipse":** This article mentions observations made by eclipse chasers in the 2001 Zambian eclipse. It also describes some of the problems facing scientists wanting to observe animal behavior for the 2012 Australian eclipse. https://www.eclipse-chasers.com/article/papers/wildlife01.html

2. Instructional Strategies:

- **"Solar Eclipse 2017: Life Responds":** When they participate in the Solar Eclipse 2017: Life Responds Citizen Science Project, students become citizen scientists and are involved in gathering data for a scientific research project on August 21, 2017. https://www.calacademy.org/citizen-science/solar-eclipse-2017
- **Photosynthesis Virtual Labs:** Students perform several virtual labs on the importance of light in the process of photosynthesis and analyze and interpret the data collected. Following this activity, students write a hypothesis about how plants will respond to the change in light and temperature during a total solar eclipse. http://www.northernhighlands.org/cms/lib5/NJ01000179/Centricity/Domain/38/photosynthesis-virtual-labs.pdf
- ***Where Birds Go at Night:*** Read the article at https://www.thespruce.com/where-birds-go-at-night-386443 . Based on the observational data in the article, students will select a bird and write about their predictions concerning the behavior of the bird during the total solar eclipse. Because of the amount of data and citizen science that will be part of this eclipse event, students could follow up with their own additional research to determine actual, observed behavior following the event in August.
- **This study reveals meteorological impact of the 2015 solar eclipse:** https://phys.org/news/2016-08-reveals-meteorological-impact-solar-eclipse.html. After reading the article, students research average mean temperature for their location and predict average temperature drop during the total solar eclipse after analyzing and interpreting the data they have read about and researched.

Sixth Grade Performance Indicator:

6.E.2B.3 *Develop and use models* to represent how solar energy and convection impact Earth's weather patterns and climate conditions (including global winds, the jet stream and ocean currents).

Effect of Total Solar Eclipse on Local and Global Weather Patterns

Essential Question: How might the total solar eclipse affect local and global weather patterns and climate conditions?

Vocabulary: solar radiation, reflection, insolation, convection, convection current

1. **Possible Introductory Activities:**

Choose from the following resources to support student engagement with the total solar eclipse and transaction with text.

Literary/Informational Texts:

- **Climate and Earth's Energy Budget:** The earth's climate is a solar powered system. This feature article from NASA's Earth Observatory website explains earth's energy budget and how absorbed sunlight drives photosynthesis, fuels evaporation, melts snow and ice, and warms the earth system. https://earthobservatory.nasa.gov/Features/EnergyBalance/page1.php
- **Solar eclipses have an effect on wind:** This *EarthSky* article briefly discusses the effect the 1999 eclipse in Great Britain had on wind patterns. http://earthsky.org/earth/solar-eclipses-have-an-effect-on-wind
- **Earth's Energy Budget: A Story:** The earth's energy budget is clearly explained in student-friendly language in the first part of this pdf document. The second part is geared more for teachers. https://science-edu.larc.nasa.gov/energy_budget/pdf/EarthsEnergyBudget-Storyboard_031913_sm.pdf
- **Surface radiation during the total solar eclipse over Ny-Ålesund, Svalbard, on 20 March 2015:** In the peer-reviewed article published in the journal *Earth System Science Data,* the authors analyze surface radiation components during totality of the March 20, 2015 eclipse in Svalbard, Norway. While the article itself is full of scientific terminology that is probably too rigorous for most middle-school students to fully comprehend, the graphs provide a data-rich springboard for class discussions about the temporary effects of a total solar eclipse on local climate. https://epic.awi.de/40719/1/essd-8-159-2016.pdf

2. **Instructional Strategies:**

- **Insolation during the 2017 Solar Eclipse:** This visualization tracks the changing insolation along the path of the August 2017 eclipse across the US. There is an activity listed under "Total Solar Eclipse Exploration Through Analyzing and Interpreting Data" which might be appropriate for those students with proficient math skills, or the activity can be scaffolded step by step by the teacher. https://svs.gsfc.nasa.gov/4466

  Other possible activities using this visualization:

  Students can identify what might be occurring inside the umbra (the black part) with ambient temperature and wind direction.
  - Explain what will happen to the ambient temperature as the eclipse begins (red) and moves through to totality (black).
- **Clouds and Convection During Totality of the Total Solar Eclipse**: When they participate in the Radiosonde Project sponsored by the University of Montana, students become citizen scientists and are involved in gathering data for a scientific research project on August 21, 2017. Students will discover how the eclipse affects convection of the atmosphere where they live during totality. The project organizers are encouraging those within the path of totality to share their cloud observations during totality. No previous experience is necessary, only a scientific curiosity. This Introduction to Clouds chart and Cloud Reporting form will help students document their observations. After they have made their observations on August 21, 2017, they may send in their data.

http://eclipse.montana.edu/radiosonde-project/#unique-identifier

- **Earth's Energy Balance:** Using modeling and mathematical and computational thinking, students perform a series of tasks that helps them form an input/output model of earth's energy budget and use scientific language appropriately to explain their newfound understanding. After forming an understanding of earth's energy budget, students can hypothesize about the local effects totality and discuss their beliefs and reasoning about whether a total solar eclipse could affect global weather patterns. https://pangea.stanford.edu/programs/outreach/climatechange/curriculum/earths-energy-balance-0

*Science and Engineering Practices

Support for the guidance, overviews of learning progressions, and explicit details of each SEP can found in the Science and Engineering Support Doc (http://ed.sc.gov/scdoe/assets/File/instruction/standards/Science/Support%20Documents/Complete_2014SEPsGuide_SupportDoc2_0.pdf). It is important that teachers realize that the nine science and engineering practices are not intended to be used in isolation. Even if a performance indicator for a given standard only lists one of the practices as a performance expectation, scientists and engineers do not use these practices in isolation, but rather as part of an overall sequence of practice. When educators design the learning for their students, it is important that they see how a given performance expectation fits into the broader context of the other science and engineering practices. This will allow teachers to provide comprehensive, authentic learning experiences through which students will develop and demonstrate a deep understanding of scientific concepts.

The SEPs are listed within the different applications of learning in this document, but can also be accessed by clicking on the SEP support document link above.

*Cross Cutting Concepts (http://www.nap.edu/read/13165/chapter/8)

The link above provides support from the Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas (2012). The text in blue and *italicized/underlined* below provides a brief explanation of how the specific content ties to the CCC's.

1. Patterns: The National Research Council (2012) states that, "observed patterns of forms and events guide organization and classification, and they prompt questions about relationships and the factors that influence them" (p. 84). *A solar eclipse occurs when the moon passes between the earth and the sun which is also the new moon phase. The angle of the moon's orbit determines when and where its shadow will actually reach the surface of the earth.*

2. Cause and effect. Mechanism and explanation: The National Research Council (2012) states that, "events have causes, sometimes simple, sometimes multifaceted. A major activity of science is investigating and explaining causal relationships and the mechanisms by which they are mediated. Such mechanisms can then be tested across given contexts and used to predict and explain events in new contexts (p. 84). *The relative positions of the Sun-Earth-Moon system cause the solar and lunar eclipses.*

3. Scale, proportion, and quantity: The National Research Council (2012) states that, "in considering phenomena, it is critical to recognize what is relevant at different measures of size, time, and energy and to recognize how changes in scale, proportion, or quantity affect a system's structure or performance" (p. 84). *Even though the sun is 400 times larger than the moon, the moon is 400 times closer to earth than the sun. Because of this, the sun and moon are the same relative size as seen from earth during a total solar eclipse.*

4. Systems and system models: The National Research Council (2012) states that, "defining the system under study—specifying its boundaries and

making explicit a model of that system—provides tools for understanding and testing ideas that are applicable throughout science and engineering" (p. 84). *Models can be used to show how motions in the Sun-Earth-Moon system cause earth phenomena.*

**Teachers have the discretion to enhance the selected SEP's and CCC's.*

Additional Resources:

Should teachers wish to provide students with additional experiences related to the total solar eclipse, the following resources are recommended.

- The Challenger Center in Columbia, SC has a site dedicated to the eclipse with links to the SC State Museum and other 2017 eclipse sites and resources. http://thechallengercenter.net/?page_id=1768
- The South Carolina State Museum website dedicated to the 2017 total solar eclipse with links and information for the week of festivities leading up to the big event. Information on activities and exhibits are listed, as well as ticket information. The exciting announcement that one of our living Moon walkers from the Apollo 16 mission, General Charlie Duke will be making an appearance on the day of the eclipse. http://scmuseum.org/eclipse/
- "An Observer's Guide to Viewing the Solar Eclipse". This is a thorough guide to help any teacher or student understand the solar eclipse phenomenon. It also includes an easy pinhole camera with explanations. http://static.nsta.org/extras/solarscience/SolarScienceInsert.pdf
- Table of present and future eclipses. http://static.nsta.org/extras/solarscience/chapter4/4.0Tables4.3And4.4FutureEclipses.pdf
- NASA Total Eclipse 2017: This website has great resources across the disciplines for students and teachers to learn more about the solar eclipse. The introductory video narrated by Data Visualizer Ernie Wright informs us about all of the sources he used in preparation of the map and on how the moon's topography affects the duration of totality. https://eclipse2017.nasa.gov/
- NASA Lesson on Eclipses: This lesson guides students through analyzing data and learning about the different types of eclipses. The final evaluation focuses on creating a brochure/advertisement for an "eclipse in your area". http://education.gsfc.nasa.gov/ess/Units/Unit5/U5L09A.html
- This is a short video from the History Channel's "The Universe" series. It is brief and a great way to introduce the phenomenon. http://css.history.com/shows/the-universe/videos/viewing-a-solar-eclipse
- Students will go on a web quest to answer questions about significant historical, mythical, and/or religious events related or attributed to solar eclipses. It is recommend that teachers modifying this quest according to student population. There are some religious implications. https://eclipse.gsfc.nasa.gov/SEhistory/SEhistory.html
- An all-encompassing website that provides information on eclipses past, present, and future. https://www.greatamericaneclipse.com/
- Eclipse Activities: There are several activities related to the total solar eclipse in Australia in 2012. Some activities require the download of a program called Stellarium, which is an easy download. http://www.eclipse.aaq.org.au/index.php/downloads/classroom-activities/solar-activities

- Solar Science: Exploring Sunspots, Seasons, Eclipses and More by Dennis Schatz and Andrew Fraknoi: *Solar Science* offers more than three dozen hands-on, inquiry-based activities for learning about solar astronomy. The activities cover the sun's motions, space weather caused by the sun, and the measurement of time and seasons in our daily lives.

References

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